Introduction to Hawaii of Malayan Parasites (Scelionidae) of the Chinese Grasshopper Oxya chinensis (Thun.) with Life History Notes

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DISCOVERY AND IMPORTATION

The immigrant grasshopper *Oxya chinensis* (Thun.) has been known in Hawaii for at least 35 years. Its spread and the increased notice of its damage to sugar cane since 1925 led the writer to undertake a study in 1930-31 of natural enemies which might attack it in the Federated Malay States. Seven species of Oxya, including *O. chinensis* have been recorded from Malacca and the Malay Peninsula.[1] Egg parasites of grasshoppers of this genus have been noted in India [2] and the assumption that parasites also occurred in the Malay Peninsula proved correct after six weeks of study.

At Serdang, in the State of Selangor, F. M. S., adult *Oxya chinensis* grasshoppers were confined in field cages resting directly on the ground and covered with large mesh wire screen. Eggs were thus obtained in the soil beneath these cages under field conditions and parasites, if present, could readily pass through the screen to reach the eggs. The egg pods were periodically removed from the soil and held in glass tubes for observation. From the first three lots of egg masses so obtained, two new species of scelionid parasites emerged in sufficient quantity for laboratory breeding operations to start immediately. These parasites *Scelio serdangensis* Timb. and *Scelio pembertoni* Timb. have since been described by P. H. Timberlake.[3]

Between December, 1930 and April, 1931, thirteen shipments of parasitized Oxya egg pods were made to Honolulu, from which about 2600 parasites, representing both species, were reared and many liberated in various parts of the Hawaiian Islands. Further breeding and liberation has continued to date (November, 1932) in Hawaii with a total distribution mostly to sugar plantations of

about 37,000 parasites. This has resulted in the known establishment of *Scelio pembertoni* in several localities where attempts to recover the parasites have been made.

Early in the breeding work in Honolulu, the species *Scelio serdangensis* gradually died out and in a few months only the one species *S. pembertoni* remained. The bulk of the liberations have hence been of the latter.

Figures 1 to 8 inclusive are given to furnish a ready means of distinguishing the two species.

LIFE HISTORY AND HABITS

The following are taken from notes and breeding data on the biology of *Scelio pembertoni*:

Oviposition:

The parasite deposits its eggs directly within those of the grasshopper. The eggs of the latter are laid slightly underground in masses of about 15 to 25, cemented and enclosed together in a white, frothy secretion which quickly hardens to a porous, brown, corky consistency forming what is commonly termed an egg pod (Figures 14 and 15). Such pods are reached by the parasite without apparent difficulty by penetration through the soil space left open over the pod when the grasshopper withdraws the tip of its body after egg deposition. Should soil fall in and completely cover the egg pod, the parasite can evidently force its small body between the loosely packed particles with ease. In laboratory breeding it was found that Scelio females would force their way through ¼ to ½ inch of coarse sand to reach Oxya egg pods so covered. As the body is compact, hard and only from 3.1 to 4.25 mm. long, no fossorial structures are present or required for the shallow penetration of soil necessary to locate Oxya eggs.

Upon reaching the grasshopper egg pod the Scelio female immediately applies the tip of the ovipositor and usually assumes the position indicated in Figure 15. Sometimes she eats a hole into the egg pod. Occasionally this may be as deep as the length of her body. When such a hole is prepared she then backs into it and commences prodding the egg pod in search of eggs in which to oviposit. The ovipositor may be described as a flexible, tubular

process 9 mm. in length and completely telescoped within the abdomen. It is clearly chitinized only for 2 mm. at the distal end. This portion consists of the two piercing blades or stylets and the stylet sheath, the tips of which are shown in Figure 9. Each stylet (Figure 9A) bears a group of about 10 well-formed, compactly placed barbs or lateral expansions about 1 mm. from the tip, as shown in the figure. It is probable that these structures, which extend backwards, facilitate oviposition by holding the ovipositor at least 1 mm. into the Oxya egg once it has been pierced and thus enabling the delicate egg of the parasite to pass well into the host egg before the guiding blades of the ovipositor are removed. The stylet sheath (Figure 9B) is not barbed. It no doubt functions as a piercing blade also since it is even more delicate and sharply pointed than the stylets.

During oviposition the ovipositor is slowly extruded and forced into the porous, corky egg pod in search of an egg. The body of the parasite, with the exception of the ovipositor parts, remains almost entirely motionless. This may last a half hour or longer. In case distant eggs in the pod are sought the ovipositor becomes extended over twice the length of the body. A close correlation exists between the size of Oxya egg pods and the greatest extension possible for the Scelio ovipositor. The longest axis of 82 egg pods deposited in moist sand and of normal shape and size was found to average 9.3 mm. and as above stated the ovipositor is capable of extension to a distance of 9 mm.

The withdrawal of the ovipositor after having been fully extended into a grasshopper egg pod is always accomplished slowly and only after much strenuous exertion. Occasionally a female may fail to ensheathe or telescope the ovipositor tube back into the abdomen after oviposition. In such cases the long, glistening, pale yellow tube remains permanently protruding and in such a state the parasite is incapable of further egg laying; but may otherwise feed and appear perfectly normal in spite of the encumbrance.

Oviposition, once started, may last for several hours without interruption. Females have been observed to oviposit or at least attempt oviposition in the same egg pod for 3 to 5 hours continuously without once withdrawing the ovipositor and with little if any change of position during the entire period. Apparently all

eggs in an egg pod may be reached by the ovipositor in such cases. Usually less than a half hour elapses before the ovipositor is withdrawn completely.

More than one Scelio egg may be placed in an Oxya egg and all hatch, but only a single parasite develops.

Parasitized Oxya eggs exhibit minute brownish spots where the Scelio ovipositor has been inserted.

Age of Oxya Eggs Parasitized:

Contrary to our expectations, Oxya eggs in all stages of development may be successfully parasitized. Vinokurov [4] has observed a Scelio in eastern Siberia which parasitizes certain grasshopper eggs only at the time the grasshopper is placing its eggs in the soil and at no other time. In the early stages of our breeding work with *Scelio pembertoni* and *S. serdangensis,* only Oxya eggs freshly laid or from 2 to 3 days old were used. These were readily parasitized. Later observations with the former species indicated that older eggs may be easily parasitized also. On November 17, 1931, fifty-three unparasitized Oxya egg pods, 14 days old, were exposed to 30 female *Scelio pembertoni* for 24 hours. From these pods parasites began emerging on December 26 and continued emerging almost daily until January 24, 1932, totaling 286 individuals.

A final experiment, using the same species, indicated that mature Oxya eggs, almost ready to hatch, may also be successfully parasitized. On November 19, 1932, twelve Oxya egg pods, 30 days old, were placed on sand in a jar containing 40 Scelio about half of which were females. These were left with the parasites for three days and then isolated in a vial for emergence records. The 12 egg pods contained a total of 196 Oxya eggs. In a few days 132 grasshopper nymphs emerged from eggs unsuccessfully parasitized and on December 27-28 a total of 64 parasites hatched from the balance of the eggs.

A small percentage of *Oxya chinensis* eggs may incubate for from 2 to 7 months longer than their normal period of about 6 weeks. Later observations have shown that *Scelio pembertoni* may successfully parasitize these old, retarded dormant embryos also.

Period of Oviposition:

Oviposition usually begins almost immediately after the emergence of the female. Egg tubes dissected from freshly hatched individuals are always found to contain many mature eggs. Should the parasite fail to locate Oxya egg pods for at least two weeks after emerging it may still successfully accomplish parasitism. Twelve females and a number of males which emerged on December 24, 1930, were held in a test tube for 14 days and fed only honey and water. At the end of this period they were exposed to 8 unparasitized Oxya egg pods for 2 days. Subsequently from these pods 77 parasites were reared. Egg laying usually occurs daily for from 8 to 14 days. Mortality naturally comes sooner with ovipositing females than with those having no opportunity to lay. They seldom live more than 2 weeks when ovipositing daily. Dissection of the egg tubes from such females at the time of death always show few, if any, well-developed eggs remaining.

Number of Eggs Deposited:

A few records have been obtained on the number of progeny of individual females. Eight freshly emerged females were confined in individual jars with several males on December 30, 1930, and daily given fresh *Oxya chinensis* egg pods until all females had died. Each pod was then saved in a separate vial to obtain the emergence record. This experiment continued until January 21, 1931, when the last female died. No progeny were obtained from females after the twelfth day. Most of the eggs were deposited at irregular intervals during the first 8 to 10 days. The following table shows the total number of progeny per female and the daily rate of oviposition. Perhaps in some cases more than one egg would be placed in a single Oxya egg. In such cases the progeny result is always one instead of two or more.

TABLE I

NUMBER OF PROGENY AND DAILY RATE OF OVIPOSITION OF 8 FEMALES (*Scelio pembertoni*)

Date of Oviposition	Number of Progeny							
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8
Dec. 30, 1930	....	8	6	....	12	1	....	9
Dec. 31, 1930	2	....	....	....	....	8	2	....
Jan. 1, 1931	12	10	3	....	....	6	....	6
Jan. 2, 1931	1	....	10	....	....	....	....	2
Jan. 3, 1931	2	6	....	19	....	....	....	....
Jan. 4, 1931	1	13	....	....	16	....	1	....
Jan. 5, 1931	....	3	....	....	....	....	....	....
Jan. 6, 1931	....	11	2	10	....	9	....	....
Jan. 7, 1931	....	....	....	....	....	....	3	....
Jan. 8, 1931	7	....	....	1	....	....	4	....
Jan. 9, 1931	5	....	....	1	....	9	....	....
Jan. 10, 1931	....	3	....	....	....	....	....	....
Total	30	54	21	31	28	33	10	17

From Table I it is seen that the greatest number of progeny obtained from a single female was 54. It is probable that under the most favorable conditions in the field this number may be greater, for from 50 to 75 fairly mature eggs can usually be dissected from the ovaries of freshly emerged females.

Parthenogenesis and Proportion of Sexes:

Normal oviposition is accomplished by unmated females. In several tests made, their progeny were always males. This is probably of considerable importance in the continued maintenance of the species, for the proportion of the sexes in field collected material has shown a preponderance of females over males. Parasitized egg pods have been under observation from which nothing but females emerged. The males usually remain over the egg pod after emerging to await the hatching of females, with which they mate immediately. Normally a well-parasitized egg pod will nearly always produce more females than males. During indoor breeding

work in Honolulu in January, 1932, an examination of 481 parasites gave 281 females and 200 males. From egg pods exposed to parasites in field recovery work in Manoa Valley, Honolulu during November, 1932, a total of 121 parasites emerging gave 97 females and only 24 males.

The Egg:

The newly deposited egg is .8 mm. long, broadly oval and terminating at the caudal end in a long slightly curved stalk as shown in Figure 10. The cephalic end is narrowed to a slight tubercle. The entire egg is placed completely within the Oxya egg. The duration of the egg stage was not accurately determined but Oxya eggs parasitized 5 days previously were found to contain Scelio larvae of the first instar.

The Larva:

The newly hatched larva (Figures 11 and 12) is most remarkable and unusual in shape and structure. Apart from the absence of legs, it bears superficially a strong resemblance to members of the collembolid genus Sminthurus. A larva of the scelionid genus Teleas quite similar was described by Ayres[5] in 1884. Packard [6] and Imms [7] consider such larvae to be the result of premature embryonic development which in most other insects would have been passed before the hatching of the egg. Similar first instar scelionid larvae have been described by Balduf,[8] McColloch and Yuasa [9] and Martin [10].

No respiratory or nervous organization is discernible, the digestive tract is blind and no body segmentation is exhibited. It is characterized by well-developed antennal processes and large weakly chitinized mandibles. The abdominal portion of the body bears about 16 strong bristles arising dorso-laterally and an elongate tapering tail-like appendage extending forward beneath the body almost to the head. The function of such processes was not determined, though they probably facilitate locomotion.

The later larval stages of Scelio were not seen.

Emergence of Adult:

Scelio adults emerge from the Oxya egg pods by chewing their way out through the corky substance enclosing the eggs. The exit

hole (Figure 14) is usually circular and barely large enough to permit the parasite to escape. An egg pod from which 15 to 20 parasites have emerged usually shows only a few exit holes. Compact, spherical egg pods sometimes have but one exit hole, through which as many as 18 parasites escaped. In general, a parasitized egg mass will nearly always have much fewer emergence holes than the number of parasites it produced.

Emergence mostly occurs between the hours of 9 A.M. and 4 P.M. and less commonly thereafter until sunset.

Longevity:

In laboratory experiments, adults seldom live much over three weeks when fed honey and water and permitted to oviposit. As already mentioned, such individuals usually die in about two weeks. When kept in subdued light and given only water they usually live for about 12 days and rarely over 15 days. Without food or water mortality usually occurs within one week.

Life Cycle:

Life cycle data on 2,755 individuals taken at Serdang and Kuala Lumpur, Selangor, F. M. S., between October 10, 1930, and April 20, 1931, indicated an average period from egg to adult of from 25 to 35 days; the shorter cycle occurring during the warmer weather. These records were mostly obtained with the species *Scelio pembertoni,* though some included *S. serdangensis.* No discernible difference was detected between the cycles of the two species. In the course of breeding the former species in Honolulu, life cycle records on 9,391 individuals have been tabulated during 1931-32. During the warmest weather the period may be as short as 25 to 26 days. During December, January and February, the shortest period from egg to adult is usually from 38 to 40 days.

In every month of the year there is considerable variation in the cycle in any given lot of parasitized egg pods. Any lot of Oxya eggs parasitized on a given date begin producing parasites from 25 to 38 days later, depending upon the season of the year and continue yielding parasites for from 10 to 25 days longer. Table II gives a typical case to illustrate the duration and variability of the life cycle of *Scelio pembertoni.*

TABLE II

Life Cycle of *Scclio pembertoni*

Oxya Eggs Parasitized	Parasites Emerged	No. Parasites	No. Days
Oct. 8, 1931	Nov. 4, 1931	35	27
Oct. 8, 1931	Nov. 5, 1931	180	28
Oct. 8, 1931	Nov. 6, 1931	132	29
Oct. 8, 1931	Nov. 7, 1931	14	30
Oct. 8, 1931	Nov. 8, 1931	12	31
Oct. 8, 1931	Nov. 9, 1931	1	32
Oct. 8, 1931	Nov. 12, 1931	4	35
Oct. 8, 1931	Nov. 13, 1931	5	36
Oct. 8, 1931	Nov. 14, 1931	7	37
Oct. 8, 1931	Nov. 15, 1931	19	38
Oct. 8, 1931	Nov. 16, 1931	13	39
Oct. 8, 1931	Nov. 17, 1931	5	40
Oct. 8, 1931	Nov. 18, 1931	4	41
Oct. 8, 1931	Nov. 19, 1931	2	42
Oct. 8, 1931	Nov. 20, 1931	11	43
Oct. 8, 1931	Nov. 21, 1931	4	44
Oct. 8, 1931	Nov. 22, 1931	2	45
Oct. 8, 1931	Nov. 25, 1931	2	48
Oct. 8, 1931	Nov. 29, 1931	1	52

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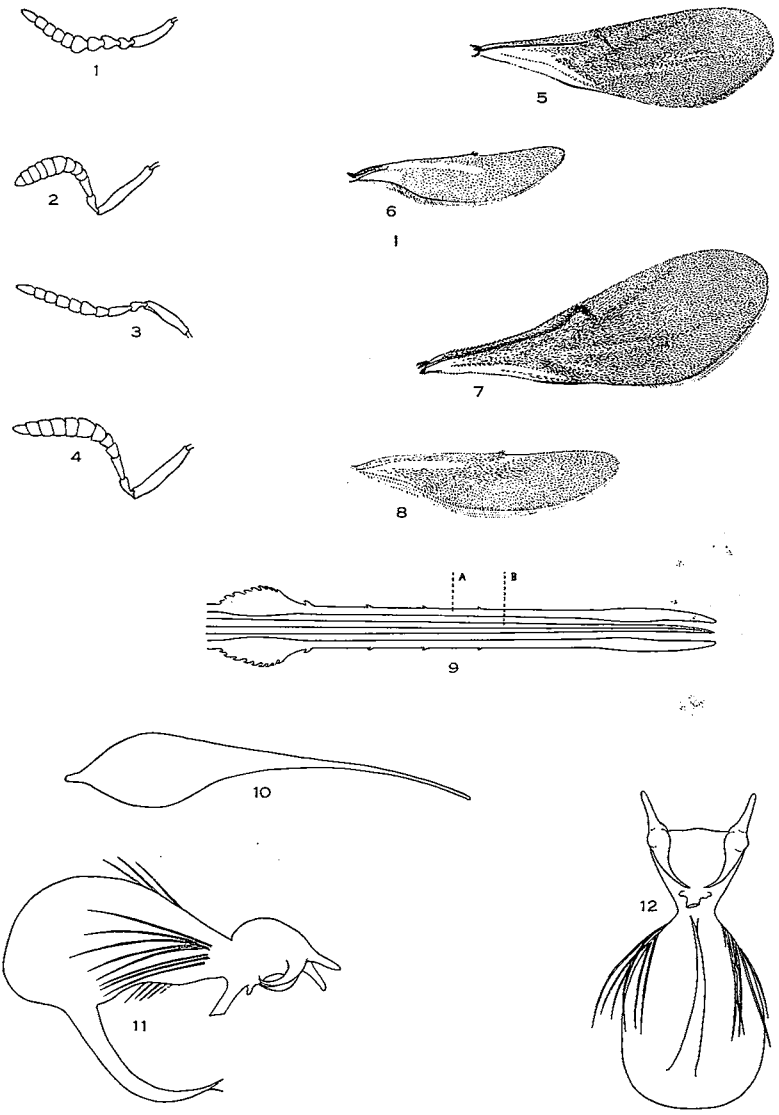
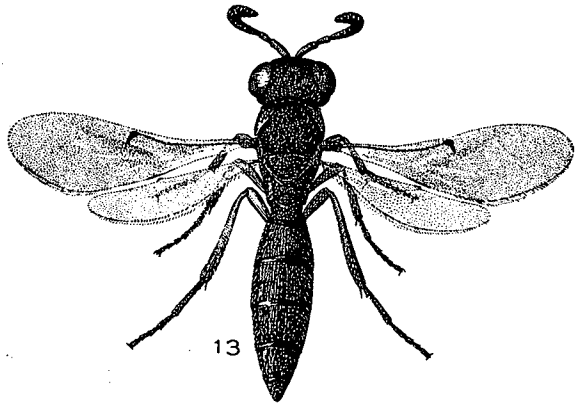
EXPLANATION OF FIGURES

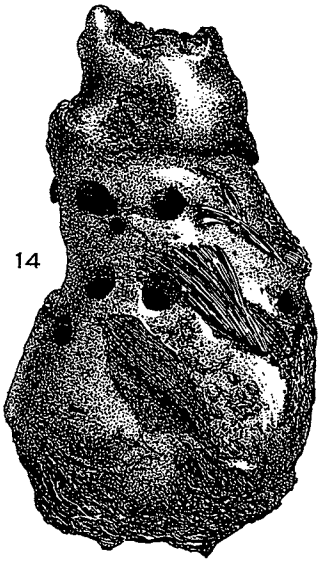
(All much enlarged)

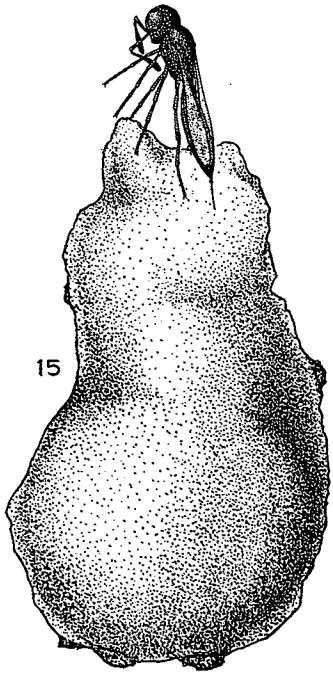
1. Antenna of male *Scelio serdangensis* Timb.
2. Antenna of female *Scelio serdangensis* Timb.
3. Antenna of male *Scelio pembertoni* Timb.
4. Antenna of female *Scelio pembertoni* Timb.
5. Forewing of female *Scelio serdangensis* Timb.
6. Hindwing of female *Scelio serdangensis* Timb.
7. Forewing of female *Scelio pembertoni* Timb.
8. Hindwing of female *Scelio pembertoni* Timb.
9. Distal portion of ovipositor blades of *Scelio pembertoni.* A. Stylet. B. Stylet sheath. Length 1.1 mm.
10. Newly deposited egg of *Scelio pembertoni.*
11. Newly hatched larva of *Scelio pembertoni* (lateral aspect).
12. Newly hatched larva of *Scelio pembertoni* (ventral aspect).
13. Female *Scelio pembertoni* Timb.
14. Egg pod of *Oxya chinensis* (Thun.), from which parasites have emerged.
15. Female *Scelio pembertoni,* showing typical position assumed when ovipositing in Oxya egg pod.



Figures 1, 2, 5, 6: *Scelio serdangensis.* Figures 3, 4, 7-12: *Scelio pembertoni.*







Scelio pembertoni